No evidence for age-related differences in item-method directed forgetting of emotional words

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Abstract

Research indicates that people can intentionally forget, but it is less clear how ageing and emotion interact with this ability. The present research investigated item-method directed forgetting of negative, neutral, and positive words in young (20-35 years), young-old (60-74 years), and old-old (75-89 years) adults. Although old-old adults showed overall reduced memory compared to young and young-old adults, all three age groups showed intentional forgetting. Moreover, intentional forgetting was not affected by the valence of the word in any of the three age groups. These findings suggest that younger and older adults can intentionally forget information that is neutral or emotional in nature. The present study's results extend previous research by showing that this ability is preserved in very old age.

Key terms: directed forgetting, emotion, intentional forgetting, encoding, ageing

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Introduction

The term forgetting often evokes negative associations and is usually considered as an undesired lapse in memory. However, forgetting can be useful in preventing outdated information interfering with currently relevant information. For example, it can be beneficial to put out of memory where you parked your car yesterday in order to remember where you left it today. Intentional forgetting is different from incidental, non-intentional forgetting, as it is an active process which requires exerting control over memory (Fawcett & Taylor, 2008).

One method for testing intentional forgetting is the directed forgetting (DF) paradigm, originally designed by Bjork (1972, 1989). In this task, participants study material on an item-by-item or a list-by-list basis, and are asked either to remember or to forget it (e.g., Basden & Basden, 1998; Basden, Basden, & Gargano, 1993). In a later memory test including all items, participants usually show greater memory for items that were cued to-be-remembered (TBR) than for items that were cued to-be-forgotten (TBF; Bjork, 1972), which is usually referred to as the DF effect. It has been suggested that selective rehearsal of TBR items and segregation of TBR and TBF items make TBR items more available than TBF items at retrieval in the item-method DF task (Basden & Basden, 1996, 1998; Bastin et al., 2012; MacLeod, 1999; Sahakyan & Foster, 2009; for a review, see Titz & Verhaeghen, 2010). Alternatively, it was suggested that forgetting in the item-method task depends on attentional inhibition of TBF items (Fawcett & Taylor, 2008, 2010; Zacks & Hasher, 1994; Zacks, Radvansky, & Hasher, 1996) during encoding, which allows release of resources for the processing of TBR items (but see Marks & Dulaney, 2001).

The DF task has attracted research interest from the domain of cognitive ageing due to evidence that ageing is associated with a reduced ability to inhibit irrelevant information (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Zacks et al., 1996). In a meta-analysis, Titz and Verhaegen (2010) analysed data from 24 experiments using the item- or list-method

DF tasks. For the item-method DF task, they reported that older adults were able to intentionally forget, but that they exhibited overall smaller DF effects than younger adults. As the item-method DF task has been linked with a number of mechanisms such as selective rehearsal, segregation of items and attentional inhibition, calculating the memory difference between TBR and TBF items does not allow determining which of the mechanisms was affected by ageing. According to the selective rehearsal account, a reduced DF effect could reflect difficulties to selectively rehearse TBR items in ageing. Alternatively, a reduced DF effect could be due to impairments in inhibiting TBF items in ageing as the inhibition framework would suggest. Indeed, studies that analysed TBR and TBF items separately have provided evidence for both accounts. Some showed that reduced retrieval of TBR items contributed to a smaller DF effect in older as compared to younger adults (Gamboz & Russo, 2002; Hogge, Adam, & Collette, 2008; Exp. 1A, Sego, Golding, & Gottlob, 2006). Others found that older adults have difficulties putting TBF items out of memory (Collette, Germain, Hogge, & Van der Linden, 2009; Earles & Kersten, 2002; Hogge et al., 2008; Zacks et al., 1996), thus providing support for the inhibition account of ageing (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Zacks et al., 1996). However, a third group of studies have found no evidence for age-related changes in item-memory DF. For instance, Sego, Golding, and Gottlob (2006) found intact DF in young and old adults using both a recall and a recognition test. Moreover, Gamboz and Russo (2002) found that age-related changes in DF can be eliminated through controlled pre-cue encoding. They asked young and old adults to encode words under “shallow” (i.e., letter counting), “deep” (i.e., pleasantness ratings) and “control” (i.e., no specific instruction) conditions before the TBR or TBF cue. Age-related impairments in DF were found under “shallow” and “control” but not under “deep” conditions, suggesting age-related differences in pre-cue processing rather than in selective rehearsal or inhibition. Overall, these findings suggest that item-method DF is not generally impaired in ageing and further investigation is needed to assess under which circumstances changes do or do not appear.

It should be noted that most studies on age-related differences in DF have used neutral material only. However, evidence suggests that emotional memory changes with age, which might affect forgetting of emotional information. According to socioemotional selectivity theory (SST; Carstensen, 1993), which is often used to explain age-related changes in emotional memory, a shrinking time horizon is associated with increased prioritisation of emotion regulation goals in ageing. Consequently, older adults are thought to allocate more resources to emotional material, resulting in relatively better memory for emotional than non-emotional material in ageing (e.g., Fung & Carstensen, 2003). Additionally, research indicates that older adults show relatively increased memory for positive and/or reduced memory for negative information compared with younger adults (Charles, Mather, & Carstensen, 2003; Mather & Knight, 2005). Within the SST framework, the “positivity effect” in ageing reflects the increased striving for emotional well-being (Scheibe & Carstensen, 2010). It was suggested that older adults’ preserved emotional processing and enhanced motivation to engage with emotional rather than neutral material might help them to perform better on emotional memory tasks (May, Rahhal, Berry, & Leighton, 2005). Despite a general, age-related memory decline (Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012; Nyberg et al., 2003; Park et al., 2002), better memory for emotional material was found to be preserved in ageing (e.g., Denburg, Buchanan, Tranel, & Adolphs, 2003; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). Age-related differences have also been found to be smaller in memory tasks with emotional than non-emotional items (Carstensen & Turk-Charles, 1994; Kensinger, 2009; May et al., 2005). Given these age-related changes in emotional memory, an intriguing question is how emotion may affect intentional forgetting in older relative to younger adults.

Focusing primarily on DF in younger adults, a number of studies have tested whether emotional material that is usually more memorable than neutral material (e.g., Brandt, Sünram-Lea, Jenkinson, & Jones, 2010; Dolan, 2002; Dolcos, LaBar, & Cabeza, 2004, 2005; Hamann, 2001; Talmi & Moscovitch, 2004) is also harder to forget in item-method DF tasks (Bailey & Chapman, 2012; Brandt, Kragh Nielsen, & Holmes, 2013; Gallant & Yang, 2014; Hauswald, Schulz, Iordanov, & Kissler, 2011; Korfine & Hooley, 2000; Nowicka, Marchewka, Jednoróg, Tacikowski, & Brechmann, 2011). A mixed pattern of results was found: Some studies reported smaller or no DF effects for emotional relative to neutral items (Bailey & Chapman, 2012; Hauswald et al., 2011; Nowicka et al., 2011), whereas others showed enhanced DF effects for negative relative to neutral words (Brandt et al., 2013). To our knowledge, only one study by Gallant & Yang (2014) has thus far investigated DF of emotional items in ageing. This study found that both young and old adults were able to forget emotional and neutral words but that overall forgetting was lower in the older sample, which was interpreted as evidence for less efficient intentional forgetting in ageing. However, there was no attempt to control pre-stimulus processing in the two age groups despite evidence that it can affect DF in ageing (Gamboz & Russo, 2002). It is possible that older adults did not process all items or that they processed them in a more superficial manner than younger adults due to age-related general slowing (Salthouse, 1996). This in turn could have contributed to less efficient encoding and reduced memory of all items including TBR items, resulting in an overall smaller DF effect in older adults. Moreover, no study so far has investigated item-method DF of emotional material in very old age. Aslan and Bäuml (2013) have showed a gradual decline of list-wise DF with age, with impairments in inhibition in adults over the age of 75 years, which were not observed in young-old adults (60 to 75 years of age). As the authors focused on list-wise DF, it is not clear whether a progressive decline could also be observed when testing young-old and old-old adults in the item-method DF task. Additionally, a presumably further reduced personal time horizon in the old-old relative to young-old and younger adults might be associated with a stronger focus on emotion and thus, potentially more pronounced effects of emotion on DF.

To gain a more comprehensive understanding of DF in ageing, the present research explored age-related differences in intentional forgetting of emotional material in three age groups: young (20-35 years), young-old (60-74 years) and old-old adults (75-89 years). The item-method DF task with negative, neutral, and positive words was used. Memory was tested with a recognition test to guard against potential floor effects in recall memory in the old age groups, which could make it numerically difficult to observe age-related changes. Participants were also asked to rate the pleasantness of the words before the cue to remember or to forget to match processing depth of study items in all three age groups. Given evidence that emotion can enhance the feeling of remembering, even if material was not previously studied (Brandt, Sünram-Lea, & Qualtrough, 2006; Sharot, Delgado, & Phelps, 2004), false alarms were also analysed in the present study. It was expected that older adults would show reduced memory with advanced age, with lowest recognition performance in the old-old group. Given previous research showing that older adults invest more cognitive resources to focus on emotional material, two different outcomes might be expected: Firstly, it is possible that older adults would be able to exert more control over emotional information due to enhanced allocation of cognitive resources. Alternatively, it is also possible that this stronger focus on emotional information would make it more difficult for older relative to younger adults to intentionally forget these items. It was expected that, should age-related differences in DF of emotional items be observed, they would be more pronounced in old-old than in young-old adults relative to young adults. To further investigate whether age-related changes would occur for memory of TBR or TBF items in an item-method DF task, these items were analysed separately rather than in a composite DF measure.

Methods

Participants

Thirty younger, 30 young-old, and 30 old-old adults participated in the study (see Table 1 for participant characteristics). Younger adults were recruited from the student body of the University of Roehampton. Older adults were recruited from the University of the Third Age in Greater London, who received a £10 gift voucher for their participation. All participants were screened for psychiatric and neurological disorders and all older adults had a score of 27 or above in the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). All participants reported to be in good health and had normal or corrected-to-normal vision and hearing. Depressive symptoms were assessed with the Beck Depression Inventory (BDI-II; Beck, Steer, & Carbin, 1988). Two younger and two old-old participants were excluded from data analysis for scoring 14 and above on the BDI-II as these scores indicate mild depression, leaving a final sample of 28 younger, 30 young-old and 28 old-old adults.

Young adults had more years of education than young-old adults, $F(1, 56) = 7.25$, $MSE = 412.18$, $p < .01$, partial $\eta^2 = .12$, and old-old adults, $F(1, 54) = 9.52$, $MSE = 434.38$, $p < .01$, partial $\eta^2 = .15$, with no difference between young-old and old-old adults ($p = .634$). Young-old adults had lower BDI-II scores than younger, $F(1, 56) = 4.95$, $MSE = 651.38$, $p < .05$, partial $\eta^2 = .08$, or old-old adults, $F(1, 56) = 4.02$, $MSE = 587.38$, $p = .05$, partial $\eta^2 = .07$, with no difference between young and old-old adults ($p = .778$). Lower scores in the Digit Symbol Substitution Test from the WAIS-R (Wechsler, 1955) indicated slower processing in the old-old as compared to young adults, $F(1, 54) = 39.96$, $MSE = 7284.96$, $p < .001$, partial $\eta^2 = .46$, and young-old adults, $F(1, 56) = 7.41$, $MSE = 7216.34$, $p < .01$, partial $\eta^2 = .13$. Processing speed was also slower in young-old compared to younger adults, $F(1, 56) = 13.55$, $MSE = 7843.39$, $p < .01$, partial $\eta^2 = .22$, a finding commonly observed in ageing research (Salthouse, 1996, 2000). Consistent with findings of preserved crystallised intelligence

(Baltes & Lindenberger, 1997; Craik & Bialystok, 2006) and findings of better vocabulary knowledge in older compared to younger cohorts (Alwin & McCammon, 2001; Bowles, Grimm, & McArdle, 2005), young-old adults outperformed young adults on the Shipley Vocabulary Test (Shipley, 1940), $F(1, 56) = 46.80$, $MSE = 537.11$, $p < .001$, partial $\eta^2 = .49$. The same pattern was observed for old-old and young adults, $F(1, 54) = 34.47$, $MSE = 560.29$, $p < .001$, partial $\eta^2 = .42$, with no difference in verbal knowledge between the two older age groups ($p = .354$). The two older age groups did not differ in performance on the MMSE either ($p = .294$). The ethics board of the University of Roehampton approved the procedure prior to the start of the study and written informed consent was obtained from each individual.

Insert Table 1 about here

Materials

The stimuli were taken from the Affective Norms for English Words word list (ANEW; Bradley & Lang, 1999) and descriptive statistics of the stimuli are provided in Table 2. Of the selected words, 60 were negative (valence ratings < 3.5 out of 9), 60 were neutral (valence ratings < 3.5 and > 6.5), and 60 were positive (valence ratings > 6.5). As can be seen in Table 2, negative and positive words were matched for arousal, and negative, neutral, and positive word lists were matched for word frequency. Half of the negative, neutral, and positive words were allocated to Set A and the remaining ones were allocated to Set B. The items in Set A and Set B were not significantly different in terms of valence ($p = .977$), arousal ($p = .957$), or word frequency ($p = .964$). Which subset was presented during encoding (and was therefore old at retrieval) was counterbalanced across participants as was the assignment of instruction (i.e., remember vs. forget) to each word.

Insert Table 2 about here

Procedure

After giving informed consent and providing demographic information, participants viewed 30 negative, 30 neutral and 30 positive words (either from Set A or Set B) in a random order on a computer screen. A fixation cross was presented in the centre of the screen for 500 ms and then replaced by a word that remained on the screen for 5000 ms. Participants rated the word as unpleasant, neutral, or pleasant by pressing one of three labelled keys. After the 5000 ms elapsed, the word was followed by a “remember” or a “forget” cue for 1000 ms. Half of the negative, neutral, and positive words were followed by a “remember” cue and the remaining words by a “forget” cue. Participants were asked to remember or to forget the word depending on the given cue.

A 15-minute distractor phase followed, in which participants completed the Beck Depression Inventory (Beck et al., 1988), the Digit Symbol Substitution Test (Wechsler, 1955) and the Shipley Vocabulary Test (Shipley, 1940). Following the distractor phase, participants performed a recognition memory task. They viewed 180 words in random order, half of which had been studied previously (either Set A or Set B), and half of which were from the alternative word set. First, a fixation cross was presented on the centre of the screen for 500 ms, followed by the word. The participants’ indicated whether they had previously seen the word (“old”) or not (“new”) by pressing one of two labelled keys and the word remained on the screen until a response was made. Participants were asked to respond regardless of the initial remember or forget instruction and to respond as accurately as possible. The study phase was preceded by 6 practice trials, with 3 being followed by a "remember" and 3 by a "forget" cue. The test phase was preceded by 12 practice trials, half of which were new. The session lasted approximately 1.5 hours in total.

Results

Participants' recognition performance was analysed by using the percentage of correctly recognised words (hits) and incorrectly recognised words (false alarms) for TBR and TBF items separately. Hits and false alarms were used to calculate *A'* and *B''* as indices of detection sensitivity and response bias (Grier, 1971) for negative, neutral and positive items to assess the role of emotion on corrected recognition. Higher bias scores indicated a conservative response bias, while lower bias scores indicated a liberal response bias. Performance for all three age groups is reported in Table 3. Following the same approach in the analyses as suggested by Bailey & Chapman (2012), detection sensitivity and response bias were not calculated separately for TBR and TBF words as it was not possible to associate false alarms with either type of trials. Instead, additional analyses were conducted using hits for TBR and TBF words to assess the effectiveness of instruction. Detection sensitivity and response bias were analysed by 3 × 3 mixed factors ANOVA including the within-subjects factor of emotion (negative, neutral, positive) and the between-subjects factor of age (young, young-old, old-old). Hits were analysed by 3 × 2 × 3 mixed factors ANOVA including the within-subjects factors of emotion (negative, neutral, positive) and instruction (TBR, TBF) as well as the between-subjects factor of age (young, young-old, old-old).

Insert Table 3 about here

Detection sensitivity. There was a main effect of emotion, $F(2, 166) = 10.37$, $MSE = .01$, $p < .001$, partial $\eta^2 = .11$, with higher detection sensitivity for neutral words than for negative words, $F(1, 83) = 19.28$, $MSE = .01$, $p < .001$, partial $\eta^2 = .19$. Detection sensitivity was also higher for neutral words than for positive words, $F(1, 83) = 5.37$, $MSE = .01$, $p < .05$, partial $\eta^2 = .06$. There was also a main effect of age, $F(2, 83) = 3.11$, $MSE = .01$, $p = .05$, partial $\eta^2 = .07$. No significant age-related differences in detection sensitivity were observed between younger (M = 76.23%, SD = 7.95%) and young-old (M = 78.11%, SD = 7.93%) adults (p = .372). However, there was a difference between young-old and old-old adults (M = 72.94%, SD = 8.01%), $F(1, 56) = 6.10$, $MSE = .36$, $p < .05$, partial $\eta^2 = .10$, indicating higher detection sensitivity in the former. There was no significant difference between young and old-old adults (p = .129). No further main effects or interactions were observed for detection sensitivity.

Response bias. There was a main effect of emotion, $F(2, 166) = 7.09$, $MSE = 28.46$, $p < .01$, partial $\eta^2 = .08$, with a more liberal response bias for negative than for neutral words, $F(1, 83) = 15.08$, $MSE = 22.55$, $p < .001$, partial $\eta^2 = .15$. Response bias was also more liberal for positive than for neutral words $F(1, 83) = 10.43$, $MSE = 26.01$, $p < .01$, partial $\eta^2 = .11$. No further main effects or interactions were observed for response bias.

Hits. Hit scores were higher for TBR than for TBF words, as evidenced by a main effect of instruction, $F(1, 83) = 26.69$, $MSE = .01$, $p < .001$, partial $\eta^2 = .24$. There was also a main effect of emotion, $F(2, 166) = 7.37$, $MSE = .02$, $p < .01$, partial $\eta^2 = .08$, with increased hits for negative relative to neutral words, $F(1, 83) = 5.94$, $MSE = .02$, $p < .05$, partial $\eta^2 = .07$. Hits were also increased for positive relative to neutral words $F(1, 83) = 11.92$, $MSE = .02$, $p < .01$, partial $\eta^2 = .13$. There was also a main effect of age, $F(2, 83) = 4.02$, $MSE = .01$, $p < .05$, partial $\eta^2 = .09$. Hit scores were lower in old-old (M = 82.54%, SD = 10.55%) than in younger adults (M = 88.10%, SD = 4.98%), $F(1, 54) = 6.35$, $MSE = .37$, $p < .05$, partial $\eta^2 = .11$. Hit scores were also lower in old-old relative to young-old adults (M = 87.52%, SD = 7.80%), $F(1, 56) = 4.22$, $MSE = .48$, $p < .05$, partial $\eta^2 = .07$. No significant age-related differences were observed between younger and young-old adults ($p = .740$). No further main effects or interactions were observed for hits.

Performance and participants' characteristics. Due to significant differences in participants' characteristics between the groups (i.e., years of education, BDI-II, Digit Symbol Substitution Test and Shipley Vocabulary Test), secondary analyses were conducted to assess whether these measures correlated with performance in the DF task and were better predictors than age. Across all age groups, years of education correlated positively with hits for neutral TBR and TBF items ($r = .34$, $p < .01$ and $r = .40$, $p < .01$, respectively). Years of education also correlated positively with detection sensitivity for neutral items ($r = .36$, $p < .01$) and negatively with response bias for neutral items ($r = -.33$, $p < .01$). Performance on the Digit Symbol Substitution Test correlated positively with hits for neutral TBR items ($r = .38$, $p < .01$) and with detection sensitivity for neutral items ($r = .33$, $p < .01$). No other significant correlations were observed between participant characteristics and performance on the DF task. Multiple regression analyses with age, years of schooling and Digit Symbol Substitution Test performance as predictors for hits for TBR items and detection sensitivity for neutral items revealed that age was not a significant predictor for these performance measures ($p = .269$ and $p = .215$, respectively). Similarly, when age and years of schooling were entered as predictors for hits for TBF neutral items and for response bias for neutral material, age was not a significant predictor either ($p = .363$ and $p = .906$, respectively).

Discussion

The aim of the present study was to investigate item-method DF of emotional and neutral words in young (20 to 35 years), young-old (60 to 74 years), and old-old (75 to 89 years) adults. It was observed that old-old adults showed overall lower hit rates than young adults and lower detection sensitivity than young-old adults. However, all participants were able to intentionally forget as they recognised more words that were instructed to-be-remembered than those that were instructed to-be-forgotten with no age-related differences. Critically, the analysis of hits for TBR and TBF items showed that the valence of words did not affect forgetting in any of the three age groups. These findings suggest that despite overall reduced memory, the ability to intentionally forget neutral and emotional material is preserved in very old age.

The finding of efficient DF in ageing is in line with work by Sego, Golding and Gottlob (Exp. 1A & 1B, 2006), who found no age-related differences in item-method DF either for recognition or for recall. The results are also in accordance with Gamboz and Russo (2002), who found no age-related differences in item-method DF when the depth of semantic processing of words was controlled for in younger and older adults. The use of controlled pre-cue processing in the current experiment might also explain why the results differed from those reported by Gallant and Yang (2014). In their study, both age groups viewed the stimuli during the study phase without having to respond to them and a reduced DF effect was observed in older adults. It cannot be excluded that age-related differences in pre-cue processing contributed to this effect rather than differences in mechanisms targeted by an item-method DF task, such as selective rehearsal or attentional inhibition. In the present study, participants were asked to rate the pleasantness of the items before a cue to match processing depth of study items in all three age groups. With this procedure, no age-related differences were observed in DF, highlighting the importance of controlled pre-cue processing. However, forgetting was relatively low overall and it is possible that, besides helping to control depth of processing, adding pleasantness ratings strengthened memory traces for all words and thereby contributed to overall small DF effects in the present study.

The present study also revealed that all three age groups were able to forget material that was emotional in nature. This is consistent with results showing successful forgetting of emotional stimuli not only in younger (Brandt et al., 2013) but also in older participants

(Gallant & Yang, 2014). The result is also in accordance with findings by Murray, Muscatell, and Kensinger (2011), who showed that young and old adults were able to suppress both neutral and emotional items when instructed to do so in a think/no-think paradigm. The present study extends previous research by showing that forgetting of emotional items is not only preserved in young-old adults but also in an old-old sample with a mean age of 79 years. It appears that despite age-related changes in emotional memory (Charles et al., 2003; Mather & Knight, 2005; Reed & Carstensen, 2012), older adults can intentionally forget emotional information even in very old age.

The results obtained in this study do not directly support socioemotional selectivity theory (SST; Carstensen, 1993) as no emotional biases were observed in the older age groups. However, the results are reconcilable with SST as it is likely that the instructions used in this study did not allow for older adults to exhibit biased processing. According to SST, the positivity effect is usually observed when there are no constraints on the participants' processing during encoding (Reed & Carstensen, 2012). In the present study, however, participants received specific instructions to rate all items for pleasantness and to remember or to forget words, thus manipulating engagement with the items actively. It is possible that no emotional biases in older adults' recognition were observed as their motivation to regulate emotions was supplanted by the instructions.

Recognition scores for TBR and TBF were analysed separately to assess whether age is associated with changes in memory for TBR items or TBF items in an item-method DF task. It was found that age did not interact with either of these two measures, suggesting that neither selective rehearsal or active inhibition, which are thought to underlie the DF effect, were affected in any of the older age groups. Despite this, an overall reduction in memory in old-old adults was observed, replicating results from previous item-method DF studies (Gallant & Yang, 2014; Exp. 1B, Sego et al., 2006; for a review, see Titz & Verhaeghen, 2010). The results of the present study are also consistent with of showing intact inhibition in older relative to younger adults in an item-method design (Exp. 1B, Sego et al., 2006). However, they are inconsistent with studies showing that older adults have difficulties inhibiting the processing of goal-irrelevant information as in the case of TBF items (Collette et al., 2009; Earles & Kersten, 2002; Hogge et al., 2008; Zacks et al., 1996). This mixed pattern of results suggests that inhibitory processes are not generally impaired in ageing. Results also showed that more years of schooling were associated with better performance on all memory measures for neutral items. Faster processing speed was also related to higher discrimination sensitivity for neutral items. Whereas these results were found for neutral items only, age-related changes in memory were observed across all items. Thus, it is unlikely that these can be fully explained by differences in years of schooling and processing speed.

Although previous research showed more efficient DF in younger relative to older adults (Dulaney, Marks, & Link, 2004; Hogge et al., 2008; Titz & Verhaeghen, 2010; Zacks et al., 1996), these results were obtained using neutral material only. It is possible that older adults benefited from the inclusion of emotional material and from focusing on the items' emotional nature through pleasantness ratings in the current paradigm. As emotion is known to trigger enhanced processing (Phelps & LeDoux, 2005) and brain regions involved in emotional detection and processing seem to be largely unaffected by age (Chow & Cummings, 2000), emotional processing might have facilitated older adults' overall good DF performance. Emotion also modulated recognition performance across all age groups, with reduced detection sensitivity and a more liberal response bias for emotional relative to neutral items. As this was found for both positive and negative words, this pattern of findings is believed to be related to the arousal rather than the valence of emotional words. It is consistent with a large body of research showing that not only true but also false memories are enhanced for emotional relative to neutral material (Brainerd, Stein, Silveira, Rohenkohl, & Reyna, 2008; Dolcos et al., 2005; Dougal & Rotello, 2007; Johansson, Mecklinger, & Treese, 2004; Kensinger & Corkin, 2003; Sharot et al., 2004; Sharot & Yonelinas, 2008). It was also suggested that increased semantic relatedness of emotional words might enhance confusability in memory and increases false memories (e.g., Buchanan, Etzel, Adolphs, & Tranel, 2006; Fazendeiro, Winkielman, Luo, & Lorah, 2005; Talmi & Moscovitch, 2004; Talmi, Schimmack, Paterson, & Moscovitch, 2007). In the present research, all three age groups showed higher false alarms to emotional relative to neutral words (and hence leading to greater memory accuracy for neutral items), which replicates findings of a preserved response bias to emotional material in ageing (Budson et al., 2006; Gallo, Foster, & Johnson, 2009; Kapucu, Rotello, Ready, & Seidl, 2008; Pierce, Sullivan, Schacter, & Budson, 2005).

In conclusion, the present research showed that younger and older adults have the ability to intentionally forget neutral and emotional material. Moreover, this research revealed that this ability is preserved in very old age despite reductions in overall memory. These findings indicate that while there are age-related changes in emotional memory, they do not extend to intentional forgetting of emotional information. Considering the importance of exerting control over emotional information for emotional functioning in everyday life, these findings might help to understand mechanisms of wellbeing into very old age.

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Appendix 1

Tables

Table 1. *Participant characteristics*

Measure	Young adults		Young-old adults		Old-old adults	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	25.11	4.73	66.97	4.27	78.93	4.06
Gender (male:female)	12:16		8:22		9:19	
Years of education	17.78	2.03	15.87	3.22	15.45	3.46
BDI II	5.89	3.93	3.90	2.85	5.61	3.61
Digit Symbol Substitution Test	67.64	12.39	53.37	11.86	45.36	11.75
Shipley Vocabulary Test	31.36	4.28	37.27	2.10	36.71	2.21
MMSE			29.23	.97	28.96	.96

Note. BDI II = Beck Depression Inventory II, MMSE = Mini-Mental State Examination

Table 2. *Stimuli characteristics*

	Range	*Minimum rating*	*Maximum rating*	*M*	*SD*
Valence ratings					
Negative words	2.22	1.25	3.47	2.42	0.60
Neutral words	1.80	4.50	6.30	5.31	0.32
Positive Words	2.01	6.59	8.60	7.67	0.53
Arousal ratings					
Negative words	3.80	3.83	7.63	5.75	0.99
Neutral words	3.41	2.92	6.33	4.07	0.65
Positive words	4.40	3.70	8.10	5.73	1.02
Word frequency					
Negative words	276.00	1.00	277.00	34.87	52.37
Neutral words	197.00	1.00	198.00	34.95	44.82
Positive words	178.00	1.00	178.00	34.68	35.85

Table 3. *Recognition performance*

Word valance	Young adults		Young-old adults		Old-old adults	
	M	*SD*	*M*	*SD*	*M*	*SD*
Negative						
Hits Remember	91.67	8.24	90.67	8.68	83.1	11.4
Hits Forget	85.48	12.58	86	13.82	83.81	15.12
False alarms	18.45	12.91	12.67	10.03	16.07	9.03
Discrimination sensitivity	72.72	9.69	76.16	8.16	71.03	9.68
Response bias	-2.62	3.11	-4.54	8.93	-3.29	7.05
Neutral						
Hits Remember	89.29	11.67	86.67	12.87	81.67	15.46
Hits Forget	85.48	11.19	80.67	13.94	75	20.26
False alarms	7.38	8.48	4.33	4.21	5.95	5.32
Discrimination sensitivity	80.41	10.96	79.74	11.14	74.86	11.76
Response bias	-0.84	1.42	-0.76	2.14	-0.49	0.94
Positive						
Hits Remember	90.48	7.58	92.22	10.66	87.86	10.9
Hits Forget	86.19	9.59	88.89	11.53	83.81	15.23
False alarms	14.17	11.02	12.44	8.57	15.24	9.62
Discrimination sensitivity	75.56	9.44	78.43	10	72.93	7.81
Response bias	-1.85	3.8	-3.92	7.5	-3.8	9.74